Teacher: _____

Student: _____

NORTH SYDNEY GIRLS HIGH SCHOOL

2022
Year 11
Yearly Examination

Chemistry

General Instructions
Reading Time – 5 minutes
Working Time – 2 hours
Write using black pen
Draw diagrams using pencil
Calculators may be used
Write your teachers name and your own name at the top of this booklet AND the multiple choice answer sheet.

Total Marks – 70

Part A – 20 Marks
Attempt questions 1-20
Allow about 35 minutes for this part
Record your answer on the Multiple Choice Answer Sheet

Part B – 50 marks
Attempt questions 21-31
Allow about 1 hour and 25 minutes for this part
Write your answers in the space provided. Adequate lines have been provided.

Chemistry

Part A – 20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet provided for Questions 1-20

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1. Which of the following is the name of the compound N_2S_3?
   A. Nitrogen sulfide
   B. Nitrogen (III) sulfide
   C. Dinitrogen trisulfide
   D. Nitrogen tetrasulfide

2. The molecular formula of caffeine is $C_8H_{10}N_4O_2$. What is the empirical formula of caffeine?
   A. $C_8H_{10}N_4O_2$
   B. $C_4H_5N_2O$
   C. CHNO
   D. $2(C_4H_5N_2O)$

3. Zinc metal reacts with sulfuric acid to produce zinc sulfate and hydrogen gas according to the following chemical equation.

   $$Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$$

   What type of reaction is shown here?
   A. redox
   B. precipitation
   C. decomposition
   D. combustion

4. Which of the following is the molar mass of sodium hydrogen phosphate (Na_2HPO_4)?
   A. 141.958 $gmol^{-1}$
   B. 76.968 $gmol^{-1}$
   C. 234.868 $gmol^{-1}$
   D. 118.968 $gmol^{-1}$

5. Which of the following chemical equations is balanced?
   A. $C_2H_5OH_{(l)} + O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(l)}$
   B. $NaOCl_{(aq)} \rightarrow NaCl_{(aq)} + O_{2(g)}$
   C. $2C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$
   D. $2NH_{3(g)} + H_2SO_{4(aq)} \rightarrow (NH_4)_2SO_{4(aq)}$

6. How many chloride ions are contained in 2.1 x 10^{-3} moles of barium chloride?
   A. 2.12 x 10^{-3}
   B. 4.24 x 10^{-3}
   C. 2.53 x 10^{21}
   D. 1.26 x 10^{21}

7. Examine the table of specific heats of four common substances.

Substance	Specific Heat (J g^{-1} K^{-1})
$I_{2(s)}$	0.214
$H_2O_{(1)}$	4.18
$Au_{(s)}$	0.129
$He_{(g)}$	5.19

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8. Which of the following characteristics applies to the use of most catalysts in a chemical reaction?

Answer	Function	Effect on activation energy	Effect on enthalpy change
A.	Slows a reaction	Lower	Higher
B.	Speeds up a reaction	Lower	Lower
C.	Speeds up a reaction	None	Lower
D.	Speeds up a reaction	Lower	None

9. Mary places 4.22 g of copper (II) nitrate into 50.0 mL of water and dissolves the solid fully. She then dilutes this 50.0 mL by placing the solution into a 250.0 mL volumetric flask and making up to the mark with distilled water.
   Which of the following correctly shows the concentration of the solution in the volumetric flask?
   A. 0.134 $molL^{-1}$
   B. 0.0900 $molL^{-1}$
   C. 0.900 x 10^{-4} $molL^{-1}$
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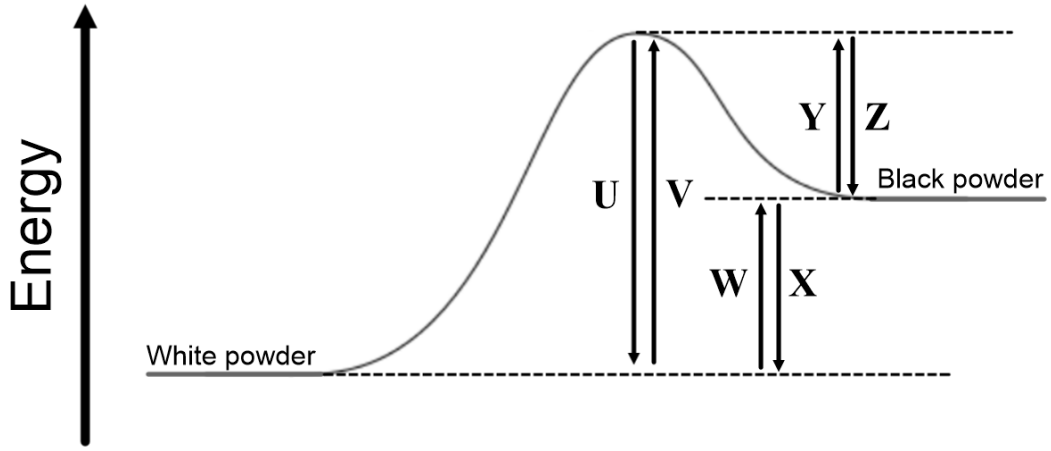
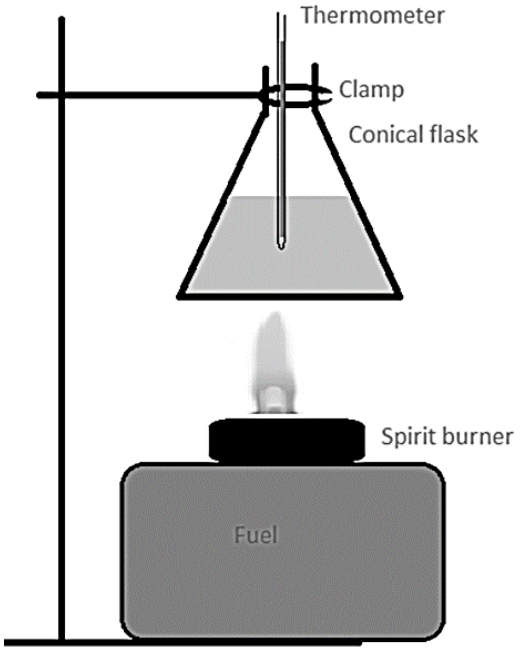
10. John places a white powder into a crucible and heats it to a high temperature. The powder changes colour to black over a period of time. Further tests show the following information.



Which of the following sets of data can be concluded from John's results?

Answer	Activation Energy	Enthalpy of reaction	Activation energy of reverse reaction
A.	W	V	Y
B.	V	X	Y
C.	V	W	Y
D.	U	W	Z

11. Sally has drawn a scientific diagram of her experiment along with her results.



Mass of burner initially	106.2 g
Mass of water	75.0 g
Mass of beaker	93.6 g
Water temp initially	18.5 °C
Water temp afterwards	36.0 °C
Mass of burner after	104.7 g

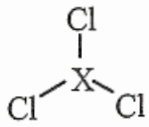
Which of the following is the heat of combustion?

A. 5486 Jg^{-1}
B. 3658 Jg^{-1}
C. 2784 Jg^{-1}
D. 2076 Jg^{-1}

12. Which of the following diagrams shows a molecule XCl_3, which is non-polar even though the X-Cl bond is polar?

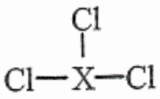
(A)

(B)



(C) Cl—X—Cl—Cl

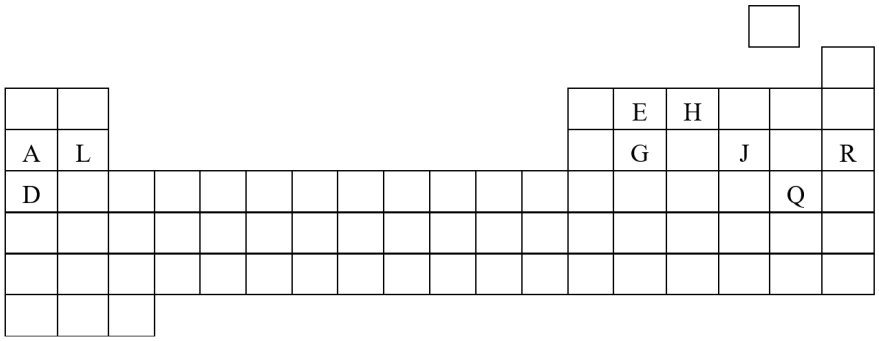
(D)



13. Silane (SiH_4) is a colourless, toxic gas with a sharp repulsive smell.
Which of the following alternatives identifies the shape and polarity of molecules of this compound?

Answer	Molecular shape	Polarity of molecule
A.	tetrahedral	polar
B.	planar	polar
C.	tetrahedral	non-polar
D.	planar	non-polar

14. For the following question refer to the diagram of the Periodic Table of the elements shown below. The letters in the diagram are not the normal symbols of the elements involved.



Which of the combinations is most likely to have the greatest difference in electronegativity?

A. A and G
B. A and D
C. L and Q
D. D and G

15. Which of the following elements would you expect to require the least amount of energy to remove the outermost electron?

A. argon
B. aluminium
C. chlorine
D. lithium

16. Mary conducts the following reaction in a laboratory.

$$KHCO_{3(s)} + HCl_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

She looks up the following charts in order to calculate the theoretical enthalpy of this reaction. These are the equations she notes down.

$$2KHCO_{3(s)} \rightarrow K_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \qquad \Delta H = 68.4 \text{ kJmol}^{-1}$$

$$K_2CO_{3(s)} + 2HCl_{(aq)} \rightarrow 2KCl_{(aq)} + CO_{2(g)} + H_2O_{(l)} \qquad \Delta H = -1553 \text{ kJmol}^{-1}$$

$$HCl_{(g)} \rightarrow HCl_{(aq)} \qquad \Delta H = -74.8 \text{ kJmol}^{-1}$$

Which of the following shows the theoretical enthalpy Mary would calculate in her reaction?

A. – 742 kJ mol^{-1}
B. – 822 kJ mol^{-1}
C. – 1485 kJ mol^{-1}
D. – 1621 kJ mol^{-1}

17. Which of the following best describes the trend of atomic radius in the periodic table?

Answer	Down a Group	Across a Period
A.	Increase	Increase
B.	Increase	Decrease
C.	Decrease	Decrease
D.	Decrease	Increase

18. Which one of the following is an example of a redox reaction?
A. $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$
B. $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$
C. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$
D. $AgNO_{3(aq)} + NaBr_{(aq)} \rightarrow NaNO_{3(aq)} + AgBr_{(s)}$

19. Hydrogen gas reacts with chlorine gas to form hydrogen chloride gas according to the following equation.

$$H_{2(g)} + C1_{2(g)} \rightarrow 2HC1_{(g)} \qquad \Delta H^o = -184 \text{ kJmol}^{-1}$$

Bond	Bond energy ($kJmol^{-1}$)
H-H	436
H-Cl	431

What is the Cl — Cl bond enthalpy for this reaction?
A. 1114 kJ mol^{-1}
B. 652 kJ mol^{-1}
C. 610 kJ mol^{-1}
D. 242 kJ mol^{-1}

20. A deposit of ore contains 36.8 % (m/m) silver (I) sulfate. Which of the following shows the mass of silver ions in 2550 kg?
    A. 107.9 kg
    B. 324.7 kg
    C. 649.3 kg
    D. 938.4 kg

PART B BEGINS ON THE NEXT PAGE

Part B – 50 marks
Attempt Questions 21 - 31
Allow about 1 hr 25 min minutes for this part

Question 21 (5 Marks) **Marks**

(a) Write full chemical equations for the following reactions:

i. Iron metal corrodes in oxygen gas to form iron (III) oxide powder. **1**

……

ii. Liquid hydrazine (N_2H_4) decomposes into hydrogen gas, nitrogen gas and ammonia gas. **2**

……

(b) A reaction is carried out in which 2.4 g of magnesium metal is reacted with excess oxygen. What will be the mass of magnesium oxide produced? **2**

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Question 22 (3 Marks)

Ammonia can be produced by reacting nitrogen gas and hydrogen gas at 25 ^oC, 100 kPa according to the equation below:

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

A scientist reacted 4.30 x 10^{-6} moles of nitrogen gas with 13.2 x 10^{-7} moles of hydrogen gas in a closed vessel.

Calculate the maximum volume of ammonia produced if the reaction proceeds to completion and no products decompose. **3**

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Question 23 (4 Marks)

A student prepared a solution by dissolving 0.173 moles of sodium carbonate powder in a 250.00 mL volumetric flask and making up to the mark with distilled water. The student then pipetted 10.00 mL of this solution into a clean, dry beaker containing 25.00 mL of 0.035 mol L^{-1} hydrochloric acid solution.

(a) Show that all the hydrochloric acid in the beaker was consumed by the reaction. **2**

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(b) Calculate the mass loss experienced by the system once the reaction is complete. **2**

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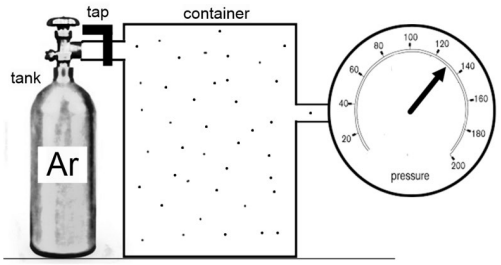
Question 24 (3 Marks)

Meredith releases Argon gas from a tank into a 2.60 L container. Her apparatus is drawn below. It includes a pressure gauge in kPa.



(a) Calculate the number of moles of Argon added when the gauge reads 130 kPa if the temperature is 25.0 ^{o}C. **2**

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(b) Meredith keeps the tap closed and heats the container to 105 ^{o}C. **1**

Calculate the new reading on the pressure gauge.

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Question 25 (4 Marks)

The table below gives the boiling point for three hydrides. **4**

Hydride	Boiling Point (^{o}C)
H_2O	100
H_2S	-60
CH_4	-161

Explain why the boiling points of CH_4, H_2S, H_2O increase in that order.

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Question 26 (5 Marks)

Phosphine (PH_3) is used as an insecticide in the storage of grain.

Phosphine can be produced by the reaction of water with aluminium phosphide, according to the equation:

$$AlP_{(s)} + 3H_2O_{(l)} \rightarrow PH_{3(g)} + Al(OH)_{3(aq)}$$

2

(a) Draw a Lewis dot diagram of phosphine.

3

(b) A fixed volume of phosphine is stored at 18 °C and a pressure of 200 bar. A temperature change causes the pressure to increase to 225 bar. Calculate the temperature change.

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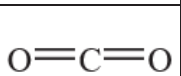
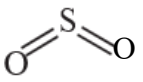
Question 27 (3 Marks)

The table below contains some information about sulfur dioxide and carbon dioxide.

Name	Shape of molecule	Electronegativity difference between elements	Solubility in water at 25 °C (gL^{-1})
carbon dioxide		1·0	1·45
sulfur dioxide		1·0	94

3

Explain why carbon dioxide is much less soluble in water than sulfur dioxide is in water.

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Question 28 (5 Marks)

(a) A group of students was investigating displacement reactions. They found when zinc was placed into a blue solution of copper sulfate, the zinc became covered with reddish-brown residue and the blue colour of the solution faded. **1**

i. Write a balanced chemical equation for this reaction.

…… **2**

ii. Write two half equations for this reaction.

……

…… **2**

(b) They also placed a piece of copper into lead (II) nitrate solution. They did not observe any reaction. Account for this result.

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Question 29 (9 Marks)

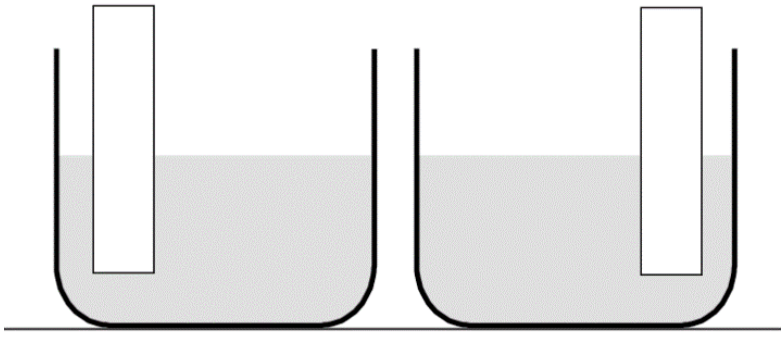
A group of students was investigating the use of different metals and their solutions in galvanic cells. They were provided with strips of magnesium, lead and silver and solutions of magnesium nitrate, lead nitrate, silver nitrate and potassium nitrate. All the solutions had 1.0 mol L^{-1} concentration.

(a) Which combination of metals has the highest potential difference? **1**

…… **5**

(b) Complete the diagram below of a galvanic cell that uses the metals identified in part (a). In your diagram, include labels for the following:

- cathode and anode
- electrolytes
- salt bridge
- direction of electron flow
- direction of ion flow across the salt bridge



2

(c) Write a balanced chemical equation for the net ionic reaction that occurs in the cell.

…… **1**

(d) Calculate the cell potential of the galvanic cell.

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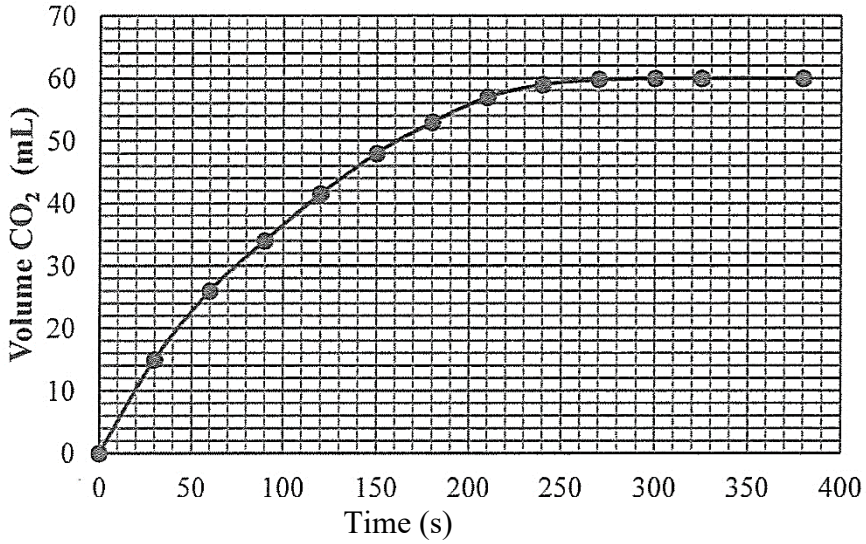
Question 30 (6 Marks)

A student conducted an experiment at 25 °C and 100 kPa to measure the rate of reaction when powdered calcium carbonate reacts with hydrochloric acid to produce carbon dioxide gas, as shown in the equation below.

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Data was collected and a graph of volume of carbon dioxide gas versus time was drawn.



(a) Using data from the graph, calculate the mass of calcium carbonate that had reacted at 220 seconds. **2**

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…… **4**

(b) Explain the trend in the graph using your understanding of collision theory.

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Question 31 (3 Marks)

The following table has some enthalpies of formation of some relevant compounds:

Compound	Enthalpy of Formation ($kJmol^{-1}$)
$CO_{2(g)}$	-393
$H_2O_{(l)}$	-286
$C_6H_{12}O_{6(s)}$	-1273

Calculate the enthalpy change for the combustion of 90.0g of glucose ($C_6H_{12}O_6$). **3**

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END OF EXAM

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Teacher: _____

Student: _____

Multiple Choice Answer Sheet

Please colour in the circle next to the correct answer.

	A	B	C	D
1.	○	○	○	○
2.	○	○	○	○
3.	○	○	○	○
4.	○	○	○	○
5.	○	○	○	○
6.	○	○	○	○
7.	○	○	○	○
8.	○	○	○	○
9.	○	○	○	○
10.	○	○	○	○
11.	○	○	○	○
12.	○	○	○	○
13.	○	○	○	○
14.	○	○	○	○
15.	○	○	○	○
16.	○	○	○	○
17.	○	○	○	○
18.	○	○	○	○
19.	○	○	○	○
20.	○	○	○	○

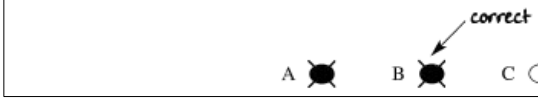
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ~~correct~~ and drawing an arrow as follows.



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Chemistry

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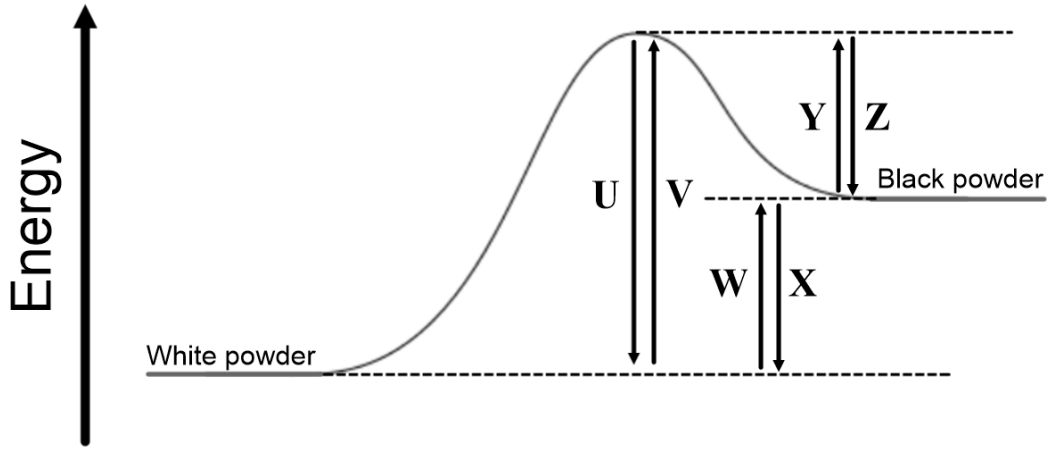

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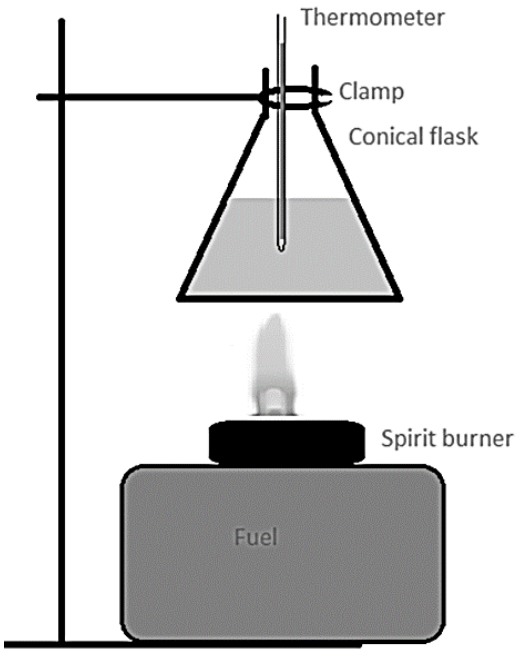

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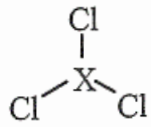
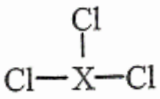


(C) Cl—X—Cl—Cl

(D)



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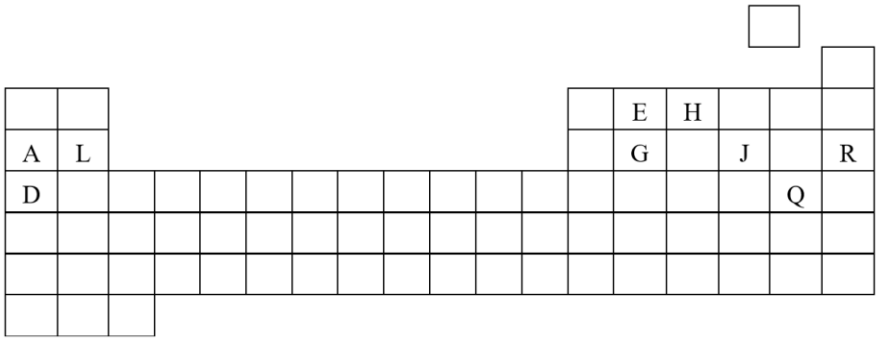
D.	planar	non-polar

14. For the following question refer to the diagram of the Periodic Table of the elements shown below. The letters in the diagram are not the normal symbols of the elements involved.



Which of the combinations is most likely to have the greatest difference in electronegativity?

A. A and G
B. A and D
C. L and Q
D. D and G

15. Which of the following elements would you expect to require the least amount of energy to remove the outermost electron?

A. argon
B. aluminium
C. chlorine
D. lithium

16. Mary conducts the following reaction in a laboratory.

$$KHCO_{3(s)} + HCl_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

She looks up the following charts in order to calculate the theoretical enthalpy of this reaction. These are the equations she notes down.

$$2KHCO_{3(s)} \rightarrow K_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \qquad \Delta H = 68.4\ kJmol^{-1}$$

$$K_2CO_{3(s)} + 2HCl_{(aq)} \rightarrow 2KCl_{(aq)} + CO_{2(g)} + H_2O_{(l)} \qquad \Delta H = -1553\ kJmol^{-1}$$

$$HCl_{(g)} \rightarrow HCl_{(aq)} \qquad \Delta H = -74.8\ kJmol^{-1}$$

Which of the following shows the theoretical enthalpy Mary would calculate in her reaction?

A. $-742\ kJ\ mol^{-1}$
B. $-822\ kJ\ mol^{-1}$
C. $-1485\ kJ\ mol^{-1}$
D. $-1621\ kJ\ mol^{-1}$

17. Which of the following best describes the trend of atomic radius in the periodic table?

Answer	Down a Group	Across a Period
A.	Increase	Increase
B.	Increase	Decrease
C.	Decrease	Decrease
D.	Decrease	Increase

18. Which one of the following is an example of a redox reaction?
A. $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$
B. $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$
C. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$
D. $AgNO_{3(aq)} + NaBr_{(aq)} \rightarrow NaNO_{3(aq)} + AgBr_{(s)}$

19. Hydrogen gas reacts with chlorine gas to form hydrogen chloride gas according to the following equation.

$$H_{2(g)} + C1_{2(g)} \rightarrow 2HC1_{(g)} \qquad \Delta H^o = -184\ kJmol^{-1}$$

Bond	Bond energy ($kJmol^{-1}$)
H-H	436
H-Cl	431

What is the Cl — Cl bond enthalpy for this reaction?
A. $1114\ kJ\ mol^{-1}$
B. $652\ kJ\ mol^{-1}$
C. $610\ kJ\ mol^{-1}$
D. $242\ kJ\ mol^{-1}$

20. A deposit of ore contains 36.8 % (m/m) silver (I) sulfate. Which of the following shows the mass of silver ions in 2550 kg?
    A. 107.9 kg
    B. 324.7 kg
    C. 649.3 kg
    D. 938.4 kg

PART B BEGINS ON THE NEXT PAGE

Part B – 50 marks
Attempt Questions 21 - 31
Allow about 1 hr 25 min minutes for this part

Question 21 (5 Marks)

(a) Write full chemical equations for the following reactions:

i. Iron metal corrodes in oxygen gas to form iron (III) oxide powder.

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

ii. Liquid hydrazine (N_2H_4) decomposes into hydrogen gas, nitrogen gas and ammonia gas.

$2N_2H_4(l) \rightarrow H_2(g) + N_2(g) + 2NH_3(g)$ – 1 deduction per error. NB only the most simple balancing is correct.

(b) A reaction is carried out in which 2.4 g of magnesium metal is reacted with excess oxygen. What will be the mass of magnesium oxide produced?p

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

$n = \frac{m}{M} = \frac{2.4}{24.31} = 9.8725 \times 10^{-2}$ mol (1 mk)

$m = nM = 9.8725 \times 10^{-2} \times (24.31 \times 16.00) = 3.9796 = 4.0$ g (1 mk)

Question 22 (3 Marks)

Ammonia can be produced by reacting nitrogen gas and hydrogen gas at 25 ^oC, 100 kPa according to the equation below:

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

A scientist reacted 4.30 x 10^{-6} moles of nitrogen gas with 13.2 x 10^{-7} moles of hydrogen gas in a closed vessel.

Calculate the maximum volume of ammonia produced if the reaction proceeds to completion and no products decompose.

1. Determine limiting reagent. Multiple methods accepted with working. Example:

$\frac{n(H_2)}{3} = \frac{13.2\ x10^{-7}\ mol}{3} = 4.4\ x10^{-7}\ mol > n(N_2)$ hence H2 is the limiting reagent (1 mk)

2. Find moles of ammonia produced

$n(NH_3) = n(H_2) . \frac{2}{3} = 13.2\ x10^{-7}\ mol . \frac{2}{3} = 8.8\ x10^{-7}\ mol$ (1 mk)

3. Find volume of ammonia

$V(NH_3) = n(NH_3) . V_M = 8.8\ x10^{-7}\ mol . 24.79\ L\ mol^{-1} = 2.18\ x10^{-5}\ L$ (1 mk)

Note: allowances were made re showing working however many students still lost marks due to failing to demonstrate their reasoning.

Question 23 (4 Marks)

A student prepared a solution by dissolving 0.173 moles of sodium carbonate powder in a 250.00 mL volumetric flask and making up to the mark with distilled water. The student then pipetted 10.00 mL of this solution into a clean, dry beaker containing 25.00 mL of 0.035 mol L^{-1} hydrochloric acid solution.

(a) Show that all the hydrochloric acid in the beaker was consumed by the reaction.

$n(HCl) = C\,.V = 0.035\ mol\ L^{-1}\,.\frac{25.00}{1000}L = 8.75\ x\ 10^{-4}\ mol$

$n(Na_2CO_3) = C\,.V = \frac{n}{V_1}.V_2 = \frac{0.173\ mol}{\frac{250}{1000}L}\,.\frac{10.00}{1000}L = 6.92\ x\ 10^{-3}\ mol$ (1 mk)

$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(s)} + H_2O_{(l)} + CO_{2(g)}$

Since $n(HCl) < n(Na_2CO_3)$ yet the reaction requires 2x as much HCl, all HCl will be consumed. (1 mk for using stoich).

(b) Calculate the mass loss experienced by the system once the reaction is complete.

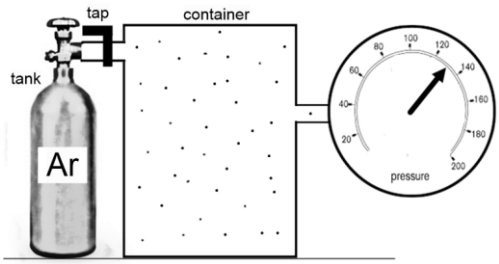
$n(CO_2) = \frac{n(HCl)}{2} = \frac{8.75\ x\ 10^{-4}\ mol}{2} = 4.375\ x10^{-4}\ mol$ (1 mk)

$m(CO_2) = n\,.M = 4.375\ x10^{-4}\ mol\,.\big(12.01 + 2(16.00)\big)g\ mol^{-1} = 1.9\ x10^{-2}g$ (1 mk)

Answer MUST be correct to 2 sig fig – deduction if this requirement was not met.

Question 24 (3 Marks)

Meredith releases Argon gas from a tank into a 2.60 L container. Her apparatus is drawn below. It includes a pressure gauge in kPa.



(a) Calculate the number of moles of Argon added when the gauge reads 130 kPa if the temperature is 25.0 ^{o}C.

$$PV = nRT \;\therefore n = \frac{PV}{RT} = \frac{130 \times 2.60}{8.314 \times (25.0 + 273.15)} = 5.9534 \times 10^{-3}\ mol$$

Students need to explicitly show calculations for conversion of temperature to gain first mark.

(b) Meredith keeps the tap closed and heats the container to 105 ^{o}C.

Calculate the new reading on the pressure gauge.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \;\therefore\; P_2 = \frac{P_1 T_2}{T_1} = \frac{130 \times (105 + 273.15)}{(25.0 + 273.15)} = 1.6488 \times 10^{2}$$

$$= 1.65 \times 10^{2}\ kPa$$

Question 25 (4 Marks)

The table below gives the boiling point for three hydrides.

Hydride	Boiling Point (^{o}C)
H_2O	100
H_2S	-60
CH_4	-161

Explain why the boiling points of CH_4, H_2S, H_2O increase in that order.

1 mark – named the forces for each

1 mark – relative strength of these forces

1 mark – correctly stated which molecule has which force

1 mark – written as an explanation using a conjunction

Students need to be aware that intermolecular forces are not bonds that require breaking. A number of students said that one or other of these molecules was “asymmetrical”, just because a molecule has a bent structure does not mean it lacks a plane of symmetry.

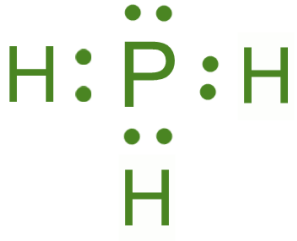
Question 26 (5 Marks)

Phosphine (PH_3) is used as an insecticide in the storage of grain.

Phosphine can be produced by the reaction of water with aluminium phosphide, according to the equation:

$$AlP_{(s)} + 3H_2O_{(l)} \rightarrow PH_{3(g)} + Al(OH)_{3(aq)}$$

(a) Draw a Lewis dot diagram of phosphine.



Ignore pyramidal structures. -1 mark if sticks used for covalent bonds.

(b) A fixed volume of phosphine is stored at 18 °C and a pressure of 200 bar. A temperature change causes the pressure to increase to 225 bar. Calculate the temperature change.

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ 1 mark

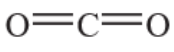
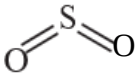
$\therefore\ T_2 = \frac{P_2 T_1}{P_1} = \frac{225 \times (18+273.15)}{200} = 3.2754 \times 10^2$ 1 mark

$\Delta T = 3.2754 \times 10^2 - (18 + 273.15) = 36.394 = 36\ ℃$ 1 mark

Some students determined T_2 without then calculating ΔT.

Question 27 (3 Marks)

The table below contains some information about sulfur dioxide and carbon dioxide.

Name	Shape of molecule	Electronegativity difference between elements	Solubility in water at 25 °C (gL^{-1})
carbon dioxide		1·0	1·45
sulfur dioxide		1·0	94

Explain why carbon dioxide is much less soluble in water than sulfur dioxide is in water.

3 marks – Explains solubility of CO_2 and SO_2 by referring to molecular shape, polarity and intermolecular forces with water.

2 marks – any two of above

1 mark – any one of above

Question 28 (5 Marks)

(a) A group of students was investigating displacement reactions. They found when zinc was placed into a blue solution of copper sulfate, the zinc became covered with reddish-brown residue and the blue colour of the solution faded.

i. Write a balanced chemical equation for this reaction.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

ii. Write two half equations for this reaction.

$$Zn(s) \rightarrow Zn^{2+} + 2e^-$$

$$Cu^{2+} + 2e^- \rightarrow Cu(s)$$

(b) They also placed a piece of copper into lead (II) nitrate solution. They did not observe any reaction. Account for this result.

1 mark – Copper less reactive than lead so will not displace it from solution/no oxidation or reduction will occur

1 mark – As a result they will observe no reaction. No lead will form on the copper**.**

Question 29 (9 Marks)

A group of students was investigating the use of different metals and their solutions in galvanic cells. They were provided with strips of magnesium, lead and silver and solutions of magnesium nitrate, lead nitrate, silver nitrate and potassium nitrate. All the solutions had 1.0 mol L^{-1} concentration.

(a) Which combination of metals has the highest potential difference?

Mg → Lead 2.36 - 0.13 = 2.23 V

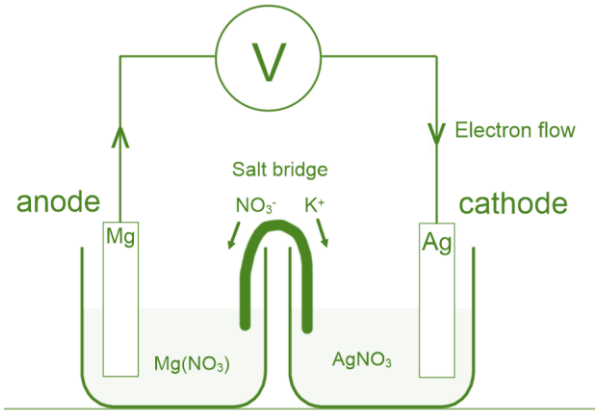
Mg → Silver 2.36 + 0.80 = 3.16 V (1 mark)

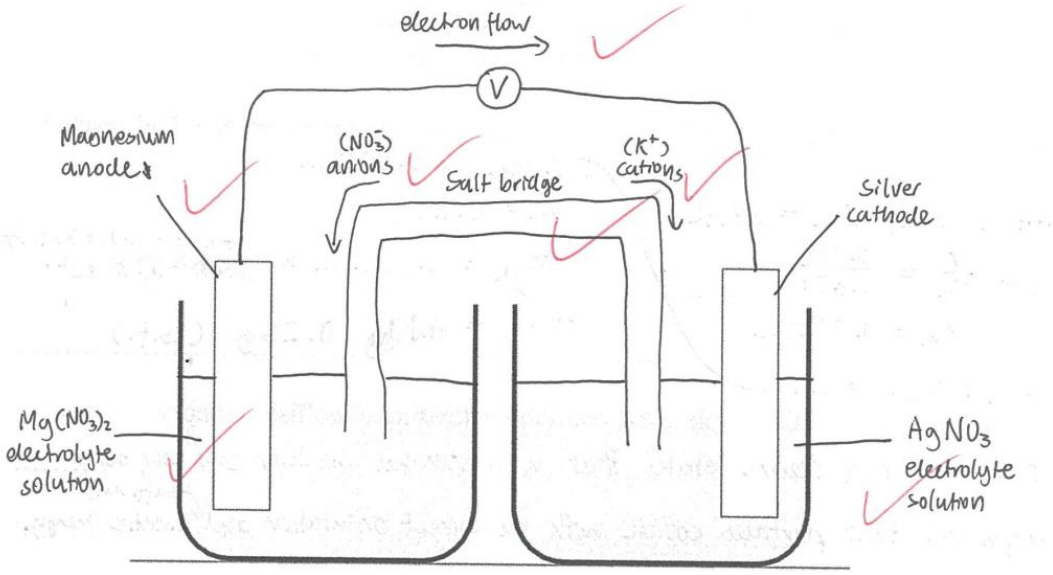
Silver → Lead -0.13 – 0.80 = 0.67 V

Note: answer included nitrate solution was not acceptable. E.g.: silver nitrate instead of silver

(b) Complete the diagram below of a galvanic cell that uses the metals identified in part (a). In your diagram, include labels for the following:

- cathode and anode
- electrolytes
- salt bridge
- direction of electron flow
- direction of ion flow across the salt bridge





- Anode and cathode labelled, could be half cell or metal electrode.
- Electrolyte formula correctly labelled. Could be shown either in solution as ions or as above, but formula was needed.
- Salt bridge labelled, if it only had a compound name was not acceptable.
- Electrolyte/solution level drawn
- Electron flow, from anode to cathode, but if anode and cathode was not correctly identified electron flow could be still correct as long as was from Mg to Ag
- Flow of ion: shown positive and negative (accepted if negative ion was correct)

(c) Write a balanced chemical equation for the net ionic reaction that occurs in the cell. **2**

$Mg_{(s)} + 2Ag^+_{(aq)} \longrightarrow 2Ag_{(s)} + Mg^{2+}_{(aq)}$

- Ions indicated
- Ions balanced,
- State symbols included

Full equations did not get marks

(d) Calculate the cell potential of the galvanic cell. **1**

$E^\circ_{(cell)} = E^\circ_{(red)} - E^\circ_{(ox)}$

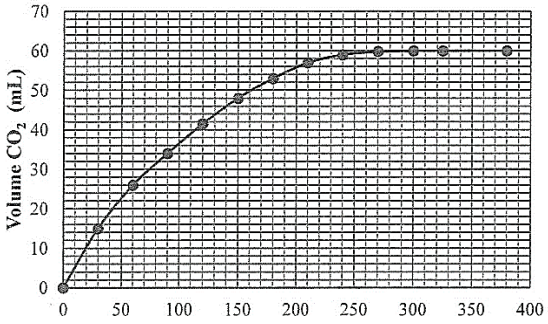
$= 0.80 - (-2.36) = 3.16\ V$

If working was shown did not deduct a mark.
But be careful: if it was a question for 2 marks or more, would not get full marks without formula!

Question 30 (6 Marks)

A student conducted an experiment at 25 °C and 100 kPa to measure the rate of reaction when powdered calcium carbonate reacts with hydrochloric acid to produce carbon dioxide gas, as shown in the equation below. $CaCO_{3(s)} + 2HC1_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

Data was collected and a graph of volume of carbon dioxide gas versus time was drawn.



(a) Using data from the graph, calculate the mass of calcium carbonate that had reacted at 220 seconds.

1 mark – correctly extracting the volume at 220 s as 58 mL, ONLY.

1 mark – substitutes values correctly into the correct equation(s).

$$m = \frac{VM}{V_M} = \frac{0.058 \times (40.08 + 12.01 + (3 \times 16.00))}{24.79} = 0.23\ g$$

Many, oh so many, students did not correctly write the molar mass of oxygen to be "16.00" but rather "16". -1 mark

Some students using the ideal gas law unnecessarily but it still worked.

(b) Explain the trend in the graph using your understanding of collision theory.

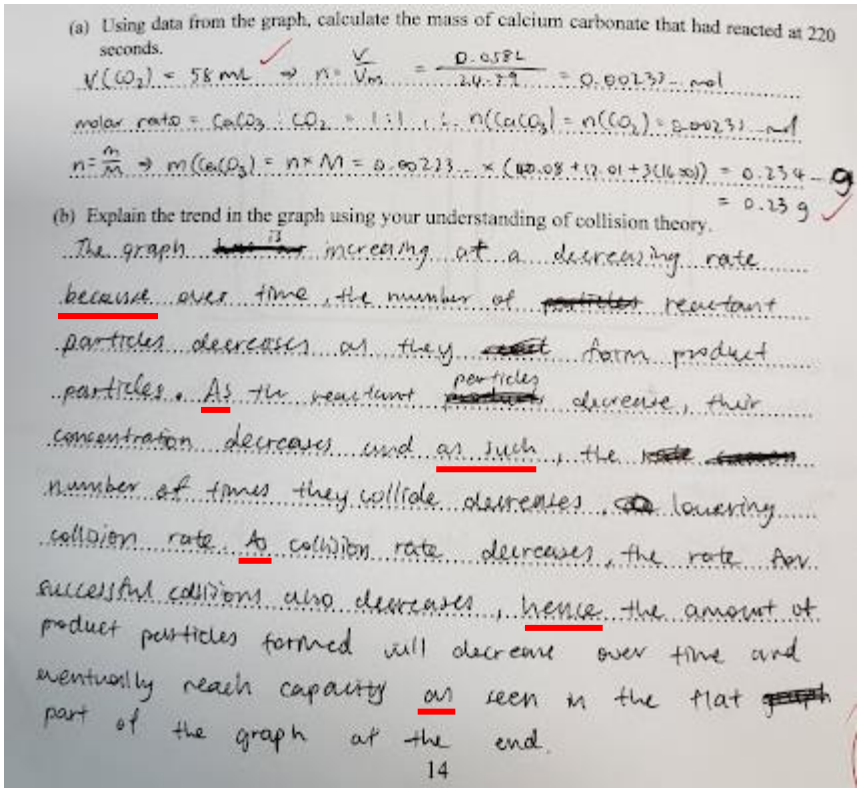
2 marks – Student states the decreasing curve to a drop-in reaction rate from 0-220 BECAUSE the number of particles is decreasing hence less collisions.

2 marks – Student states the plateau as no reaction occurring BECAUSE one (both) of the reactants has been used up completely hence no collisions.

From the first few papers it was clear students performing at a Band 6 level were identifying the two main shapes of the graph as the increasing volume at a decreasing rate from 0-220s and the second section of the plateau. As such, the marking criteria was changed to award these students as it would in the HSC.

Students who used scientific conjunctions to link cause and effect were able to succinctly identify the particle theory principle to the shape of the graph section. Failure to use conjunctions meant a vague interpretation followed and usually resulted in loss of mark due to misunderstanding or lack of LINKING between cause and effect (principle and graph).

The following is a student sample that does not necessarily show a full mark answer but rather significant effort to apply conjunctions to cause and effect.



(a) Using data from the graph, calculate the mass of calcium carbonate that had reacted at 220 seconds.

$V(CO_2) = 58\ mL \Rightarrow n = \frac{V}{V_m} = \frac{0.058}{24.79} = 0.00237\ mol$

molar ratio $CaCO_3 : CO_2 = 1:1 \therefore n(CaCO_3) = n(CO_2) = 0.00237\ mol$

$n = \frac{m}{M} \Rightarrow m(CaCO_3) = n \times M = 0.00233 \times (40.08 + 12.01 + 3(16.00)) = 0.234\ g$

$= 0.23\ g$

(b) Explain the trend in the graph using your understanding of collision theory.

The graph ~~has~~ is increasing at a decreasing rate because over time, the number of ~~particles~~ reactant particles decreases as they ~~react~~ form product particles. As the reactant ~~particles~~ particles decrease, their concentration decreases and as such, the ~~rate~~ number of times they collide decreases, ~~so~~ lowering collision rate. As collision rate decreases, the rate for successful collisions also decreases, hence the amount of product particles formed will decrease over time and eventually reach capacity as seen in the flat ~~graph~~ part of the graph at the end.

14

In the future:

- Stop saying “non-linear” as a description. We don’t care what it isn’t. We care what it is. State the actual shape!
- Stating the intro to collision theory got you nothing and waisted precious space. “Collision theory states that particles must have enough kinetic energy and the correct orientation to react.” None of these are relevant to the question. Those 6 lines you used up should have been on the simple fact that “less reactants means less collisions”.

Question 31 (3 Marks)

The following table has some enthalpies of formation of some relevant compounds:

Compound	Enthalpy of Formation ($kJmol^{-1}$)
$CO_{2(g)}$	-393
$H_2O_{(l)}$	-286
$C_6H_{12}O_{6(s)}$	-1273

Calculate the enthalpy change for the combustion of 90.0g of glucose ($C_6H_{12}O_6$).

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ (1 mark – correct formula equation)

$\Delta H_{comb} = \Sigma\Delta H_{prod} - \Sigma\Delta H_{react}$

$= (6 \times -393) + (6 \times -286) – (-1273 + (6 \times 0))$

$= -2801$ kJ mol^{-1} (1 mark – correct formation of equation using coefficients from equ)

$$n = \frac{m}{M} = \frac{90}{(6 \times 12.01) + (12 \times 1.008) + (6 \times 16.00)} = 0.49957$$

$\Delta H_{expt} = -2801 \times 0.49957 = -1399.3$

$= -1400$ kJ (1 mark – correct application of moles of glucose in 90.0 g)

Most forgot the 90.0 g in the question and ended with 2801 kJ mol^{-1}. Lost the last mark.

Rounding error – if you calculate the number of moles to be 0.49957 and you put 0.5 in your next equation, regardless of how correct your answer is, you will loss a mark for rounding your data prior to the final answer. Keep all the decimal places on your calculator and write at least 5 on the page in case you clear your calculator. -1 mark for this mistake.

END OF EXAM